

# ANNALS OF SURGERY

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VOL. XLIV

NOVEMBER, 1906

No. 5

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## ORIGINAL MEMOIRS.

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### DISLOCATION OF VERTEBRÆ IN LOWER CERVICAL REGION, FOLLOWED BY SYMPTOMS OF COMPLETE SEVERANCE OF THE SPINAL CORD; LAMINECTOMY; LATER PARTIAL RESTORATION OF FUNCTION.\*

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**CASE HISTORY.**—Fred. M., twenty-two years of age, a healthy, athletic young man, after diving into shallow water, July 4, 1905, became semi-unconscious and devoid of power over his arms and legs. A masseur, who was present when he was removed from the water, asserted that when he then examined him there was a dislocation of the spine in the cervical region which he reduced on the spot by manipulation. Four hours later he was received at the Buffalo General Hospital, in the following described condition:

There exists total paralysis of both legs; the arms and hands are partially paralyzed. Speech, eyes, pupils and facial muscles are not affected; the head is slightly retracted, but moves in all directions, with some pain, however. A careful examination of the spinal column does not reveal any fractures or dislocations. There is some tenderness about the spinous process of the fifth cervical vertebra, also some indefinite pain about the third thoracic

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\* Read before the American Neurological Association, June 5, 1906.

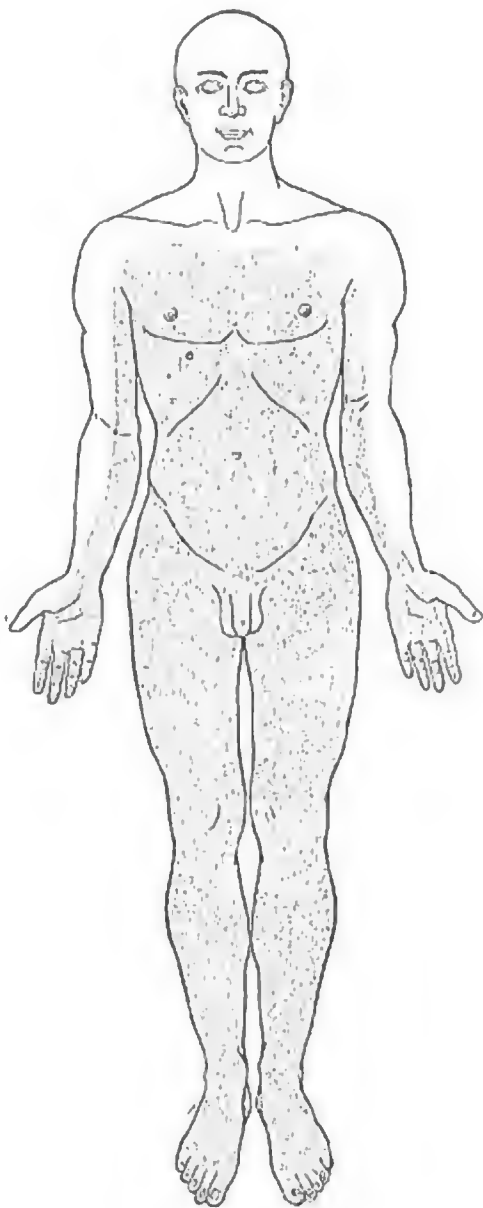


FIG. 1.—Area of total paralysis of sensation.

spine. The pulse is slow, but full, regular and of good tension. The heart is normal; no temperature.

The patellar, ankle and plantar reflexes are absent. Marked priapism is present; catheterization is necessary. The patient is able to flex the arms but not to extend them. He was transferred to the surgical ward, in charge of Dr. William C. Phelps, with whom I saw him on the following day, July 5, 1905.

Examination shows him to be a man five feet eight inches in height, weighing 150 pounds; muscles well developed; offering no scars, contusions or discolorations of any kind on his head or body. There is absolute loss of motion of the trunk and legs; limited motion of the arms, and rather free motion of the head, but attended with pain. He lies with head somewhat retracted because of relief from an aching pain when the head is flexed. As he lies on his back, the respiration attracts attention, in that there is no chest expansion, no movement of the thorax whatever in inspiration or expiration. On the contrary, the abdomen is unusually active in respiration, showing the well-marked characteristics of abdominal or diaphragmatic breathing; thoracic breathing is absolutely wanting. Extreme priapism, causing the patient considerable pain and inconvenience, is present; the head and face offer nothing abnormal. The dorsum of neck about the fifth and sixth cervical region is painful to pressure, but no crepitus or deformity of any kind is discoverable; the spine caudad of the painful area is normal.

*The Arms; Motion.*—Movements of the thumb and fingers are impossible. Extension and flexion of the forearms are possible but greatly weakened. Adduction of the arm, pronation and supination of the forearm are very weak. There is considerable weakness of the deltoids, biceps, triceps and chest muscles; also the muscles about the scapula, which has the appearance of the "winged scapula," due to paralysis of the serratus magnus. Triiceps and biceps tendon reflexes are absent.

*Sensation.*—There is a zone of anæsthesia corresponding to the level of the second intercostal space ventrally, limited to the ulnar side of the arm and forearm, including the middle, ring and little fingers (Fig. 1). The thumb and forefinger only give normal sensation. The limitation of anæsthesia affects both arms symmetrically, and is for both temperature and tactile senses. The abdomen is tense; the abdominal reflex is lost; likewise the

cremasteric. Priapism noted, makes catheterization painful. There is involuntary discharge of feces.

*The Legs.*—Absolute loss of motion; not even the toes respond.

*Sensation.*—Anæsthesia is present.

*Reflexes.*—The patellar tendon reflexes are not obtainable even with Jendrassik's method. Achilles tendon reflex and Babinski's sign are absent; likewise the plantar reflexes.

The general condition of the patient is good. Eats well, sleeps fairly good, no pain; no temperature; pulse 85; heart and lungs are normal.

The patient was immediately placed on a water-bed and extension applied to the head.

*Diagnosis.*—The complete paralysis of the legs, partial paralysis of the arms, and loss of all reflexes, together with the area of anæsthesia, led to a diagnosis of complete severance of the cord. The painful area over the fifth and sixth cervical spinous processes, together with involvement of the posterior thoracic or respiratory nerves of Bell, the phrenic nerves remaining intact, pointed to involvement of the cord at the level of the sixth cervical vertebra. An operation was suggested, but denied if absolute recovery could not be promised.

During the next few days the condition remained about the same; bed-sores began to develop on the sixth day, and a mild degree of cystitis appeared. The incontinence of feces and priapism persisted, the latter under the continual use of ice and camphor monobromate subsiding partially. Reflex contractions in the feet and legs appeared, and the patient experienced darting pains in the arms and legs. The condition remaining the same as regards motion, sensation and the sphincters, his strength failing, bed-sores growing larger, and the cystitis more pronounced, a most urgent demand was made for an operation if the young man's life were to be saved. The mother reluctantly consented, and the patient was transferred to the care of Dr. Roswell Park, whose report follows:

"July 22, 1905, under chloroform, I exposed the spine between the fourth cervical and first dorsal, finding the sixth cervical apparently somewhat loosened and abnormally movable, but without fracture so far as I could discover. I removed the posterior arch of the sixth and exposed the spinal canal. Outside the dura

nothing appeared abnormal. Upon puncturing the dura a large amount of cerebrospinal fluid escaped with a jet, showing that intraspinal tension had been very much increased. After opening the dura for one inch, the cord itself showed no particular evidence of laceration or violent disturbance, but seemed to have shrunk; was flattened so that it did not nearly fill the canal. There was a small remnant of old clot within the dura. On lifting the cord with an artery needle, it seemed flattened, ribbon-like, shrunken and to lack in bulk. I could find no evidence of present displacement of the vertebræ, and examination above and below indicated that the spinal canal was ample and afforded sufficient accommodation for the cord. I closed the dura with catgut and the entire wound with buried and superficial drainage.

"The wound healed kindly. Patient remained in the hospital about four weeks and went home, showing some improvement, able to move the feet a little, and with considerable improvement in sensation. In the hands and arms not much change appeared."

The patient remained in the hospital until August 18, 1905, gaining somewhat in strength; the bed-sores had healed, the cystitis disappeared, and he was able to sit up in a roller-chair. A small fistulous opening in the operation field was still present.

His condition is as follows: With exception of the fistula, the wound has healed by first intention. He experiences no pain about the head or neck and can move the head freely. The area of anæsthesia has not changed materially; if anything it is more of a hypæsthesia. He can now feel the contact of a pin, but cannot distinguish between the sharp and dull point; temperature sense still disturbed. He has fields of hyperæsthesia located in the legs, on the soles of the feet, and on the left knee.

*Motion.*—He is able to raise the arms over his head, can flex the forearms, and has fairly good extension of the hand, but the flexors of the hand are weak; likewise pronation and supination. He can draw up the right leg as far as the left knee; extension and flexion of the right foot is quite strong. The left leg can be drawn up to about the middle of the right leg. Extension and flexion of the left foot present, but very weak. He has better control over the legs when lungs are inflated.

*Reflexes.*—The patellar tendon reflexes are markedly exaggerated. Ankle and patellar clonus present; likewise exaggerated plantar reflexes and Babinski's. The abdominal reflex

also the cremasteric are still absent. The priapism has disappeared, and he can tell when bowels and bladder are to act, but cannot control the sphincters. The breathing remains the same, being entirely diaphragmatic. Involuntary contraction of the muscles of the legs and spasmodic flexion of the legs and feet annoyed him greatly.

With directions for further treatment, he was allowed to go to his home in Wellsville, N. Y., and was placed under the care of Dr. G. H. Witter. Reports from time to time showed continuous improvement, so that in his roller-chair he was able to go back to the office, and in a small way resume his work as telegraph operator.

On April 17, 1906, he returned to the hospital for observation and treatment.

*Stature.*—He inclines slightly forward, but can stand for fifteen minutes without support. Romberg is slightly present. Can flex right leg upon thigh and upon pelvis, standing on left leg, but can lift left leg only three inches from floor standing on right leg.

*Gait.*—He is able to walk when supported, or when pushing a chair as a guide. If he could control the tendency to fall backwards, he could walk easily with a cane. The gait is spastic; he is able to lift the right leg from the floor in walking, but drags the toe of the left foot. The left leg is considerably weaker than the right. In bed he is able to draw up the right leg freely, but barely able to draw up the left. On sitting without support, he is obliged to balance the body with his feet to prevent falling backward. He says his back is the weakest part and arches out to a great degree if not supported. He has all the motions of the arms and shoulders freely.

*Forearms.*—Pronation and supination are good; likewise the extension of the wrist. He closes the right hand fairly well, and can write very easily and use the telegraph key with force. Dynamometric test, repeated trials, averages 30.

*Left Arm and Hand.*—Incomplete pronation and supination of forearm are present. He can open and close the hand but without much power. Dynamometric test, repeated trials, averages 10.

He began to use the telegraph key on November 1, 1905,

using the wrist instead of the fingers. About March 1, 1906, he telegraphed easily and sent 5000 words over the wire.

Circumference.	Right Arm.	Forearm.	Left Arm.	Forearm.
Upper third, . . .	10 inches.	9¼ inches.	9¾ inches.	8¾ inches.
Middle third, . . .	9 inches.	7½ inches.	8¼ inches.	7 inches.
Lower third, . . .	8¼ inches.	5¾ inches.	7½ inches.	5½ inches.

Faradic irritability of the right and left arms and legs is well preserved. There is no marked difference between the two sides.

*Reflexes.*—The tendon reflexes of the triceps, biceps and forearm muscles are exaggerated. Muscle reflexes are also heightened. The abdominal and cremasteric reflexes are absent. The tendon reflexes of the legs are all exaggerated—patellar, achilles; Babinski's sign can be elicited by simply touching the soles of the feet. Patellar and ankle clonus are present and the plantar reflexes are unusually active.

*Sensation.*—There is still some difference of sensation at the level of the original zone; a mild degree of hypæsthesia still exists. In the left leg, temperature and tactile sense are normal, but in the right leg, although the patient can feel the condition of the leg and foot as to being warm and cold, he cannot distinguish between hot and cold applications to the leg. Tactile sense is normal. Breathing is still diaphragmatic. The bowels are constipated, bladder functions normally and priapism has long since disappeared. The scar, five inches in length, extends from the third cervical to the second thoracic vertebra. The spinous processes of these vertebræ are gone.

The subject of severe injury to the cord through fracture, gunshot or other insult, has received considerable attention during the past few years, and was a topic of general discussion at the 1905 Meeting of the American Surgical Association. It seems to be agreed that however severe the lesion, even to complete severance of the cord, surgical measures should be resorted to as soon as possible. The symptoms of complete severance of the cord as stated by Thomas<sup>1</sup> are:

- I. Complete paralysis, usually of a flaccid type.

2. A complete loss of sensation in all its forms.
3. Absent reflexes, especially the knee jerk, while the plantar reflex, on the contrary, is often retained.
4. Complete paralysis of the bladder and rectum, with priapism.
5. Vasomotor paralysis, with severe sweating in the paralyzed parts.
6. And most important absence of variations in the symptoms.
7. Absence of irritative phenomena, such as pain.

Walton<sup>2</sup> in a comprehensive paper on "Spinal Fracture with special reference to the question of operative interference," arrived at the following conclusions:

(1) There are no symptoms which establish (otherwise than through their persistence) irremediable crush of the cord.

(2) While total relaxed paralysis, anaesthesia of abrupt demarcation, total loss of reflexes, retention, priapism and tympanitis, if persistent, point to complete and incurable transverse lesion, the onset of such symptoms does not preclude a certain degree at least of restoration of function.

(3) The prognosis without operation is grave.

(4) While the results of operation are not brilliant, they are sufficiently encouraging to warrant us in making the practice more general.

(5) In most cases it will be wise to operate within a few days of the injury, but a delay of some hours is advisable, partly on account of shock and partly to eliminate the diagnosis of simple distortion.

(6) We have no infallible guide to the extent of the lesion. The operation at the worst does not materially endanger life nor affect unfavorably the course of the case, and may at least reveal the lesion and lessen the pain; it may sometimes save a patient from death or from helpless invalidism of most distressing character. Instead of selecting the occasional case for operation, we should rather select the occasional case in which it is contraindicated (the patient with great displacement



of vertebræ, the patient with high and rising temperature, the patient plainly moribund, the patient still under profound shock).

(7) The dura should be opened freely; it need not be sutured; drainage is not necessary.

Burrell<sup>3</sup> in a summary of all the cases of fracture of the spine which were treated at the Boston City Hospital from 1864 to 1905, states his conclusions as follows:

1. That fractures of the spine may well be divided into two classes: first, fractures of the spine with injury to the cord; and second, fractures of the spine without injury to the cord.

2. That it is not best to decide what the treatment of an individual case of fracture of the spine should be from the statistics, because the lesion varies so widely.

3. That in many cases of fracture of the spine it is impossible to primarily state whether the cord is crushed or pressed upon by bone, blood or exudate except by an open operation.

4. That only by the persistence of total loss of reflexes, complete insensibility to touch and pain, and motor paralysis below the level of the lesion can total transverse destruction of the cord be diagnosticated.

5. That if pressure on the cord is allowed to remain for many hours, irreparable damage to the cord may take place.

6. That unless it is perfectly clear that the cord is irremediably damaged, an open operation to establish the condition of the cord and to relieve pressure is imperative as soon as surgical shock has been recovered from.

7. That in certain cases of fracture of the spine, when the cord is not injured, but is liable to injury from displacement of the fragments of a vertebra, rectification of the deformity and fixation of the spine may be used.

8. That if the cord is crushed, no matter what treatment is adopted, there will, of necessity, be a high rate of mortality.

There is no question but that a complete transverse lesion was present in the case reported, by the appearance of the cord as found by Dr. Park and by the symptoms and their persistence up to and following the operation, fifteen days after the

injury. That a very decided regeneration of the cord has taken place, with a remarkably excellent result, is evidenced by his condition as stated at the present time.

In the Stewart-Harte case, the operation was performed three hours after the injury, a gunshot wound completely severing the cord, and regeneration did occur.

Fowler<sup>4</sup> in his paper in the symposium of spinal-cord lesions, reported a case in which a bullet-wound was received at the tenth and eleventh thoracic segments, completely severing the cord, in which an operation was performed and the cord sutured ten days after the operation. Regeneration of the cord followed and a partial recovery of the patient has taken place.

A timely experimental investigation of the occurrence of traumatic degeneration and regeneration of the spinal cord has been recently made by Fickler,<sup>5</sup> who experimented on the lower animals. As the result of the study of the process of regeneration in the spinal cord, Fickler notes the following:

"The regenerative phenomena following experimental lesions of the cord in animals are not as marked as those following compression of the cord in human beings. Section of the white substance between the anterior horns and the periphery is followed by regeneration of reserve fibers above and below the point of section. A regeneration of ganglion cells in the cord has not yet been observed. Regeneration of nerve fibers occurs in many diverse diseases of the cord, whether the disease has already run its course or whether it is slowly developing; it occurs in traumatism, compressions, syringomyelia, and in transverse and disseminate myelitis. It does not occur in the columnar degenerations and in multiple sclerosis. In order that regeneration may occur it is necessary that the ganglion cell should be intact. The first evidence of regeneration is seen one week after the section, and the process proceeds slowly. Only a comparatively small number of fibers are restored. The functional result is not a very considerable one. The best conditions for a restoration of function in the anterior part of the cord are afforded by compression, which leaves intact the central veins and the general configuration of

the cord. A regeneration proceeding from the posterior roots in compression has not yet been found, and probably, cannot occur, since the cause of injury of the cord is a caries of the vertebræ, which causes tuberculous ulceration of the ganglia on the posterior roots, in which case no regeneration can occur."

This case is a notable one. First, because the injury undoubtedly was a dislocation of the sixth cervical vertebra, according to the report of the masseur and the loosened condition of the sixth cervical vertebra as noted by Dr. Park at the operation; second, that a crushed or pinched condition of the cord followed, as adduced by the condition of the cord at the operation, which was borne out by the clinical symptoms, answering to all the tests of a complete transverse severance of the cord; third, that a regeneration of the spinal cord followed the operation, accompanied by a descending degeneration of the cord; fourth, and that a remarkable recovery of function took place, although the operation occurred fifteen days after the receipt of the injury.

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- <sup>3</sup> ANNALS OF SURGERY, October, 1905, p. 481.
- <sup>4</sup> American Surgical Association, 1905.
- <sup>5</sup> Deutsche Zeitschrift für Nervenheilkunde, July 13, 1905, abstracted by Jelliffe in Journal of Nervous and Mental Disease, April, 1906, page 294.